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Department of Environmental Quality Engineering
Division of Water Supply and
Montachusett Regional Planning Commission

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EROSION AND SEDIMENTATION CONTROL GUIDELINES

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MICHAEL S. DUKAKIS
GOVERNOR

JAMES S. HOYTE
SECRETARY

ANTHONY D. CORTESE, Sc.D
COMMISSIONER

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Anthony D. Cortese, Commissioner, DEQE
M. Ilyas Bhatti, Director, Division
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David Terry, Director, Water Supply Planning & Development Section
Mohammed Khan, Planning Director, MRPC

Paula Milner, Erosion and Sedimentation Project Manager, DEQE, author
Deborah Dachos, Regional Planner, Montachusett Regional Planning
Commission, author
Nancy Cranker, Environmental Planner, Mystic Urban Runoff Program,
DEQE, editor
Diane Ferullo, DEQE, typist

Disclaimer

This report has been prepared in compliance with Section 208 of the Federal Clean Water Act and has been approved for publication. Approval does not signify that the contents necessarily reflect the views and policies of the Environmental Protection Agency.

Preface

These Erosion and Sedimentation Control Guidelines were prepared by the Department of Environmental Quality Engineering in conjunction with the Montachusett Regional Planning Commission. The development of the guidelines was made possible through financial assistance from the Environmental Protection Agency, Section 208 of PL 92-500.

These guidelines were developed to aid those plan reviewers, enforcers, developers and engineers involved in erosion and sediment producing activities, to improve their understanding of the erosion process and their selection of appropriate control measures.

It is hoped that the Erosion and Sedimentation Control Guidelines will provide useful background information on erosion control to be supplemented with more detailed documents containing standards and specifications as necessary.

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INTRODUCTION

THE EROSION PROCESS

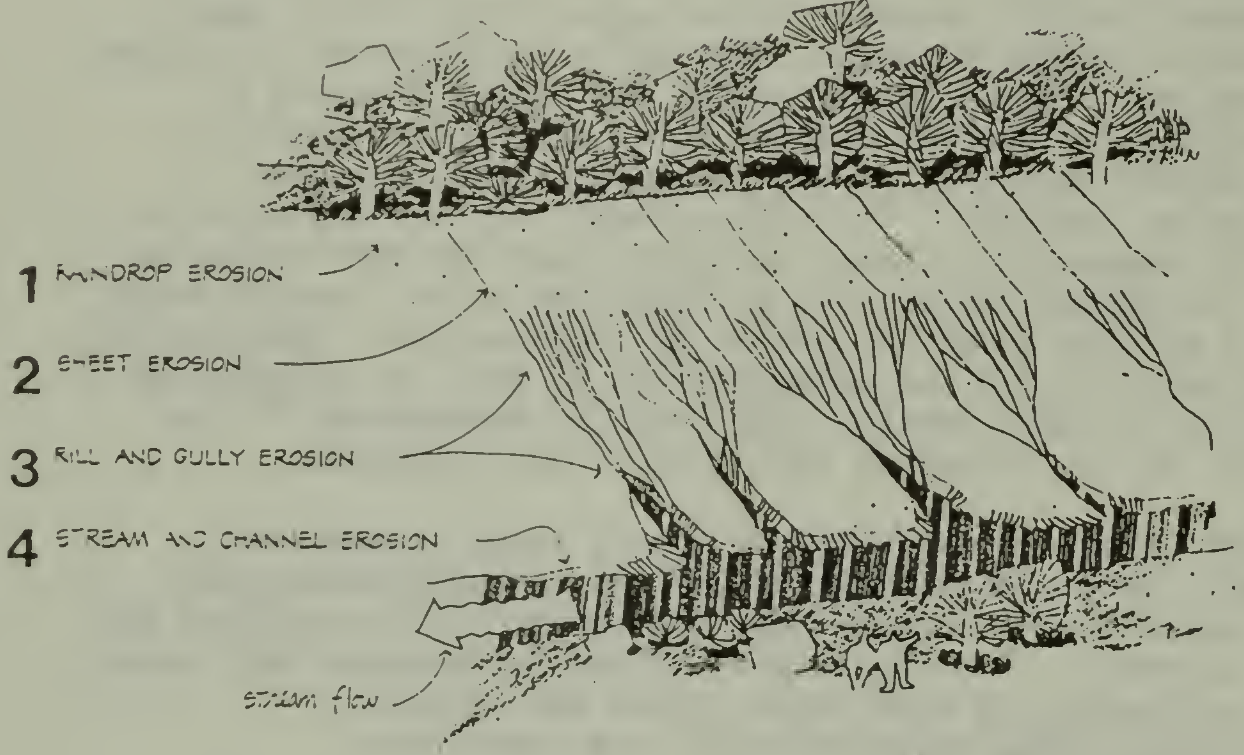
The earth's surface is subject to the erosive forces of water, wind, ice, and gravity. Different combinations of these natural forces result in differing degrees and rates of erosion. In the earth's geologic history, erosion has been responsible for the wearing away of mountain ranges and the creation of tremendous gorges or canyons such as the Grand Canyon. This type of natural erosion, termed "geologic erosion", produces approximately 30% of the total sediment in the U.S. The remaining 70% occurs when man alters the natural landscape. The erosion process resulting from man's intervention is called "accelerated erosion". Construction causes the greatest amount of accelerated erosion. The rate of erosion from construction sites is 10 to 20 times faster than that of the second greatest source of sediment, erosion on cropland. It is also highly visible and results in the filling of reservoirs, lakes, and ponds, and the destruction of small streams. In Massachusetts, 3.1 million tons of soil erodes every year. One third of this amount is caused by construction. Construction related erosion accounts for the production of 36 tons of sediment per acre which is 7 to 10 times greater than soil can regenerate.(3) By volume, sediment is the greatest pollutant of our waterways.

Soil erosion occurs as water moving down a slope loosens and removes soil particles. The soil particles are transported with the water to some location down stream. The transported soil particles are referred to as sediment. The four major factors influencing the amount of erosion and sedimentation which takes place are climate, soil characteristics, slope characteristics and vegetation.

Rainfall is the most important climatic consideration. Runoff occurs when the rate of rainfall exceeds the intake capacity of the soil. The frequency, intensity and duration of rainfall as well as the soil characteristics all affect the amount of runoff that takes place. Runoff begins as a layer of water flowing uniformly over the ground. This is called sheet erosion. As particles of soil are dislodged, water becomes confined to the area of concentrated flow. These include natural channels, rills, and gullies (Figure 1).

Soil characteristics are another important factor influencing erosion. Soil texture, structure, organic matter content and drainage characteristics influence the ease of detachment of the soil particle and the amount of runoff which occurs. In general, coarse-textured, well-drained soils, such as gravels, and gravel and sand mixtures, are the least erosive. Soils which contain large proportions of silt and very fine sand are usually highly erodible due to the ease with which these particles are detached and carried away. Clays are usually highly resistant to detachment. However, clays are transported easily and settle out very slowly, making clay sediments quite damaging to aquatic environments. Soil drainage influences the amount of runoff which is produced from rainfall, with poorly drained soils producing more runoff than well drained soils. Organic matter prevents soil from eroding rapidly by improving the stability and permeability of the soil.

FIGURE 1 (4)



TYPES OF EROSION CAUSED BY FALLING AND FLOWING WATER

1 RAINDROP EROSION: Erosion resulting from the direct impact of falling drops of rain on soil particles. This impact dislodges soil particles and splashes them into the air. The dislodged soil particles can then be easily transported by the flow of surface runoff.

2 SHEET EROSION: The removal of a layer of exposed surface soil by the action of raindrop splash and runoff. The water moves in broad sheets over the land and is not confined in small depressions

3 RILL and GULLY EROSION: As runoff flows it concentrates in rivulets, cutting several inches deep into the soil surface. These grooves are called rills Gullies may develop in unrepaired rills or in other areas where a concentrated flow of water moves over the soil.

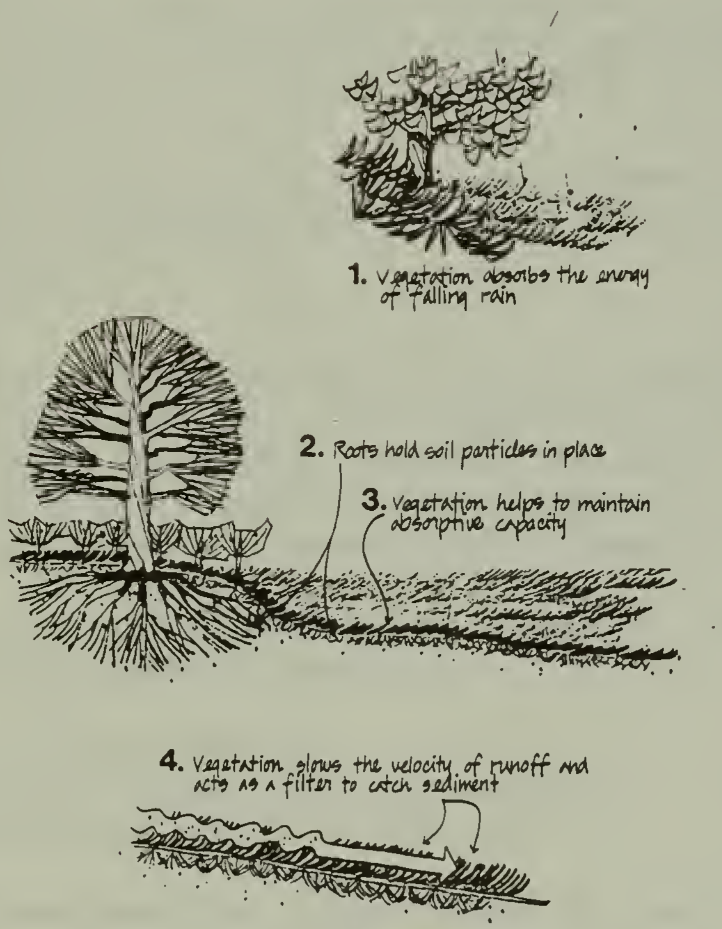
4 STREAM and CHANNEL EROSION: Increases in the volume and velocity of runoff may cause erosion of the stream or channel banks and bottom.

A quick method for determining soil erodibility is the shake test. A soil sample and clear water are mixed together in a clear container. They are then forcefully shaken and allowed to settle. If the soil settles quickly, causing the water to clear in less than one minute, the soil is thought to be of high erodibility; if it clears in one to three minutes, medium erodibility; and if it stays cloudy for more than three minutes, it is of low erodibility.

The amount and velocity of runoff are influenced by the size, shape, length, precipitousness and surface characteristics of the slope. Areas with steep slope gradients, long slopes, or sloping areas with highly erodible soils are all susceptible to erosion problems due to the increased rate and quantity of runoff.

The presence of vegetation in an area affects the amount of erosion and sedimentation that will occur, since bare soils are more susceptible to erosion than vegetated soils and are not capable of filtering out sediments. Four ways in which vegetation helps to reduce erosion and sedimentation are illustrated in figure 2.

FIGURE 2 (4)


1. Vegetation absorbs the energy of falling rain
2. Roots hold soil particles in place
3. Vegetation helps to maintain absorptive capacity
4. Vegetation slows the velocity of runoff and acts as a filter to catch sediment

EROSION SENSITIVE AREAS

Erosion and sedimentation can be greatly reduced if sensitive areas are identified and proper control measures are utilized. Highly erodible soils, whether on slopes or flat surfaces need to be stabilized. In addition to stabilization, sloping conditions may require changes designed to reduce runoff velocity by minimizing the slope length and the slope gradient.

Streams and other waterways are extremely sensitive to erosion and sedimentation. Stabilization of stream banks and measures designed to trap the sediment before it reaches the water body are ways to decrease the occurrence of erosion and sedimentation in these areas. Also the channelling of runoff away from exposed areas can lead to accelerated erosion when large quantities of water are released to drainage/ways. Drainage/ways should be adequately designed, constructed and maintained to reduce erosion, sedimentation, and/or flooding.

BEST MANAGEMENT PRACTICES FOR EROSION SENSITIVE ACTIVITIES

Some activities are particularly conducive to accelerating the erosion process. For example, construction in areas requiring land clearing and grading, and soil excavating and stockpiling are activities which can potentially result in erosion and sedimentation. Sound management practices during these operations are fundamental in reducing the amount of erosion and sedimentation that takes place.

Construction activities are a prime cause of accelerated erosion in Massachusetts. Construction in areas requiring land clearing and grading should adhere to the following practices whenever possible:

(1) Regions of the site should be developed in separate increments so that the disturbed area can be kept to a minimum.
(2) Natural vegetation should be retained and protected. Trees are particularly sensitive to construction activities and are often killed or permanently damaged by heavy construction vehicles. Procedures for protecting and saving trees and shrubs are given in Appendix 1.
(3) Construction equipment for land clearing should be operated on the land contours. This aids in minimizing soil loss.
(4) Reshaping the ground surface to provide sites more suitable for building should always be accompanied by a grading plan specifying safeguards to be used for erosion control.
(5) Whenever possible, keep runoff from concentrating in high volumes or velocities, avoid having to resort to end of pipe treatments.

The excavation and stockpiling of soil is another activity which is highly susceptible to erosion. It is important to divert runoff from the excavation area. Stockpiles placed on the uphill side of an excavation area help to divert runoff. Best management practices necessitate that stockpiles be shaped and seeded with a temporary cover.

As each phase of the excavation is completed, the following steps should be adhered to whenever possible:

(1) Sides should be graded.
(2) Topsoil should cover the exposed area.
(3) Permanent cover should be planted.

These best management practices should be used in conjunction with the control measures described in these guidelines. Specific problems at the site will determine which control methods are appropriate.

EROSION AND SEDIMENTATION CONTROL

EROSION/SEDIMENTATION PROBLEM CONTROL MATRIX

Frequently, assessment of a site will indicate that a number of situations must be addressed concurrently. For example, slope stabilization, a reduction in runoff velocity and a method for trapping sediment may be required simultaneously at one site.

The Erosion/Sedimentation Problem Control Matrix, which follows, was designed to provide the reader with an easy means of relating a control method to the function or functions it performs, facilitating cross-referencing of both control methods and purposes. A description of each control method indexed is given in a later section.

	Purpose							
Control Measure	Soil Stabilization	Slope Stabilization	Reduce Slope Gradient	Improve Drainage	Reduce Runoff Velocity	Divert Runoff	Trapp Sediment	Streambank Stabilization
Temporary Vegetative Cover	X	X		X	X		X	X
Permanent Vegetative Cover	X	X		X	X		X	X
Filter Strips				X	X		X	
Grassed Waterways				X	X	X	X	
Matting or Netting	X	X						
Mulching	X	X		X	X			
Straw Bales			X			X	X	
Scarification		X	X	X	X	X		
Filter Fence		X			X		X	
Filter Berm					X		X	
Gabions	X	X			X			X
Riprap	X	X			X			
Retaining Walls		X	X					
Diversion Ditches			X		X	X		
Diversion Dikes			X		X	X		
Level Spreaders					X	X		
Lined Waterways						X		
Down Drain Structures		X				X		
Sediment Basin							X	

CONTROL MEASURES

This section includes a description of each control method indexed in the problem control matrix. This description contains a brief definition of the measure; an illustration, where applicable; construction guidelines; and comments. Additional information and detailed procedures for using specific measures are provided in the Appendices.

Both vegetative and structural control methods have been included. Vegetative control measures are relatively inexpensive, simple and can be implemented by the non-professional. On the other hand, structural control measures tend to be more expensive and complex. Many of the structural controls must be designed by a professional engineer.

The degree of complexity of the method used will depend upon many site specific variables such as scope, and soil characteristics, however some generalizations can be made. For example, the sensitivity of the water resource to sedimentation will influence the type of control required. While vegetated marshes may be adequately protected from sedimentation by straw bales, water supply tributaries may require large sediment basins for full protection. Climatic conditions and relative storm size will also influence the type of control which is required.

TEMPORARY VEGETATIVE COVER

Stabilization of sediment producing areas which will be bare > 2 months but < 12 months by planting with fast growing grasses.

CONSTRUCTION GUIDELINES

- Temporary Cover: (10)

	Seeding Rates in Lbs. Per		Recommended
Species	1,000 Sq. Ft.	Acre	Seeding Dates
1. Annual Ryegrass	1	40	March 1 - June 15 Aug. 15 - Sept. 15
2. Sudangrass	1	40	May 15 - Aug. 15
3. Millet	1	30	June 1 - Aug. 1
4. Winter Rye	3	120	Aug. 15 - Oct. 15

COMMENTS

- See Appendix 1 for Seeding Directions.
- See page 14 for mulching guidelines.
- See page 13 for matting guidelines.

PERMANENT VEGETATIVE COVER

Stabilization of sediment producing areas which will be bare >12 months by establishing a herbaceous cover through seeding or sodding.

CONSTRUCTION GUIDELINES

for seeding:

- Type of maintenance program to be provided should be decided before species are selected.
- Seed mixture should be suited to soil moisture conditions.
- Legumes should be included in seed mixes in areas where regular fertilization cannot be relied upon.

for sodding:

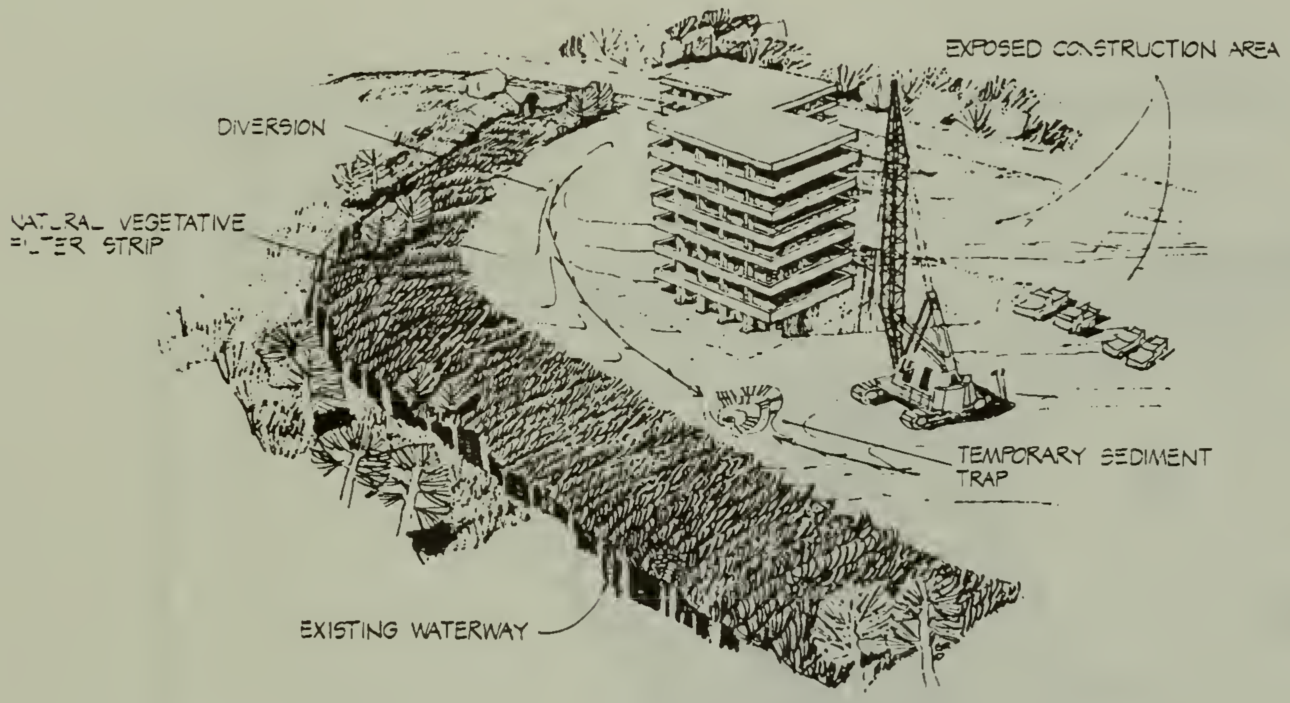
- Criteria for selecting sod should include soil moisture characteristics, shading and other growing conditions so that plant species is adaptable to the site.
- Grass sod which requires mowing should not be used on slopes steeper than 3:1.
- Sod strips two feet wide can be used to define seeded areas.
- A checkerboard pattern or sodding and seeding of rectangles or squares can be used on steep slopes.

COMMENTS

- Immediate protection is provided with sodding, so this method is particularly effective in critical areas.
- See Appendix 3 for Seed Mixture Suggestions.
- See Appendix 2 for Seeding Directions.
- See Appendix 5 for Soil Moisture Conditions.
- See Appendix 4 for Sodding Procedures.
- See page 13 for information on using matting to help establish a vegetative cover.

VEGETATIVE FILTER STRIP

Naturally occuring or man made strip of well established vegetative cover retarding surface flow and causing the deposition of sediment.



NATURAL VEGETATIVE FILTER STRIPS HELP TO MINIMIZE SEDIMENTATION

(4)

Construction Guidelines

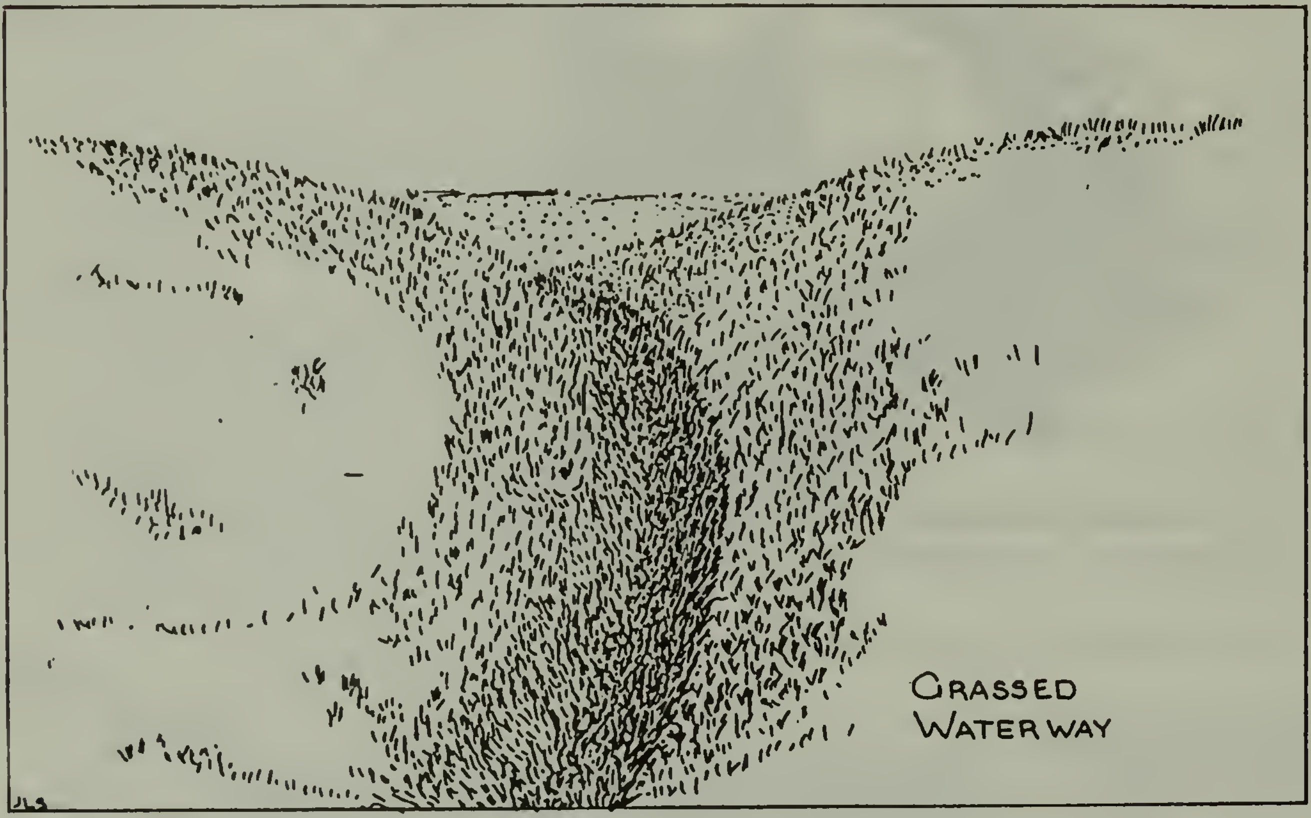
- Man-made grasses may be provided by sod or by planting.
- Typical widths of vegetative filter strips:
  Above diversions: 15' plus ½ of channel width.
  Along live streams: 100'

Comments

- Tall, dense stands of grasses form the best sediment traps.
- See Appendix 2 for Seeding Directions.
- See Appendix 3 for Seed Mixtures for Permanent Cover.
- See Appendix 4 for Procedures for Sodding.

GRASSED WATERWAY OR OUTLET

A natural or constructed waterway shaped and graded and established with suitable vegetation to slow runoff flow, filter out pollutants, and allow for infiltration.



CONSTRUCTION GUIDELINES

- Bottom width $\leq$ 50'.
- Should be designed to carry a 10 year storm.
- Recommended covers:(10)

Cover	Slope Range (Percent)
1. Reed canarygrass	0-5
Tall Fescue	5-10
Kentucky bluegrass	Over 10
2. Grass-legume**	0-5
Mixtures	5-10
3. Red fescue	0-5***
Redtop	
4. Annuals****	0-5
Sudangrass	
Small grain	
(rye, oats, barley)	
Ryegrass	

COMMENTS

- Inspection and maintenance are required.
- Channel must be stabilized.
- See Appendix 2 for Seeding Directions.

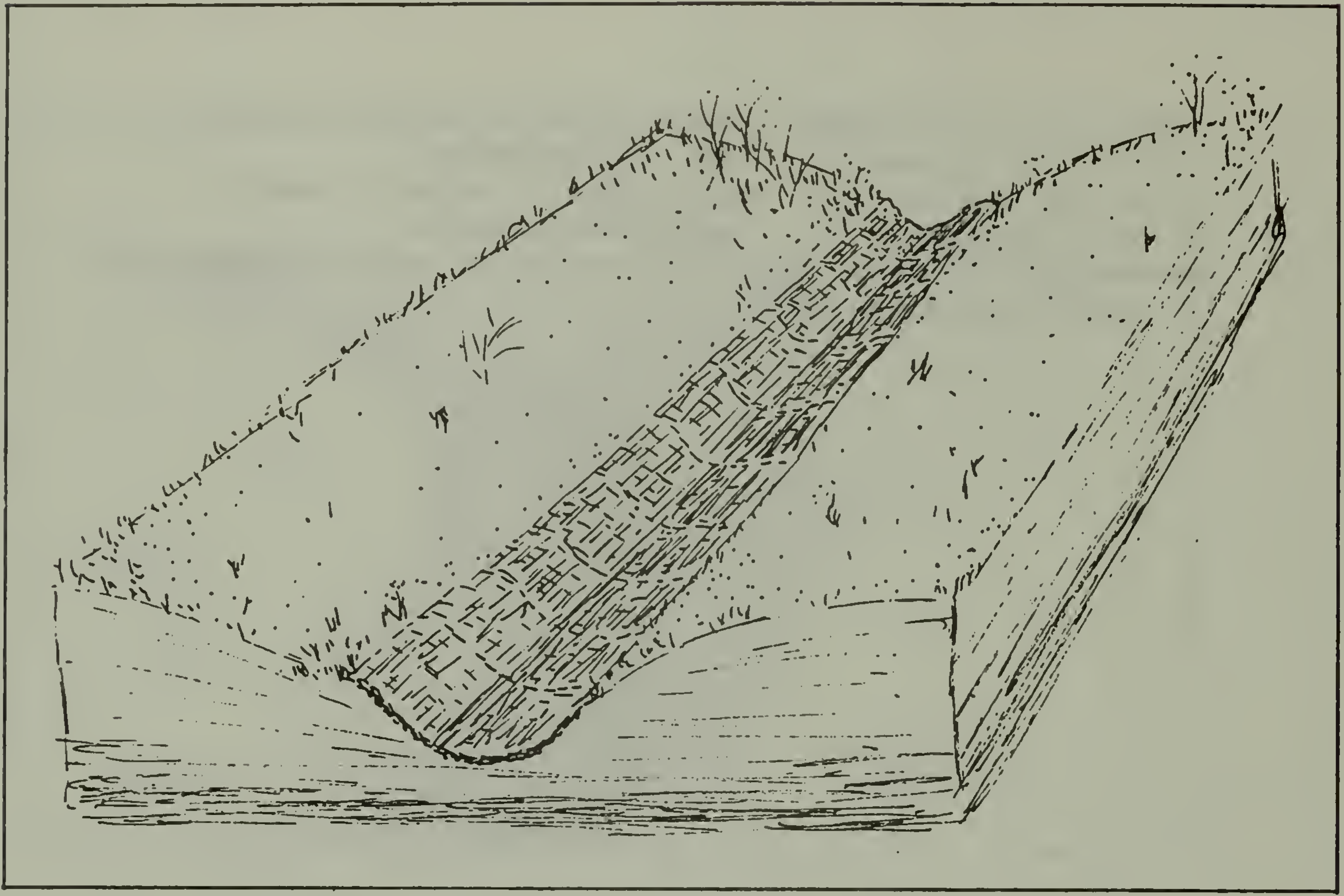
**Do not use on slopes steeper than 10 percent, except for side slopes in a combination channel.

***Do not use on slope steeper than 5 percent, except for side slopes in a combination channel.

****Annuals - use as temporary protection until permanent covers are established.

MESH OR BLANKET MATTING

Method for stabilizing erodible areas during the development of vegetative cover.



CONSTRUCTION GUIDELINES

- Fibers may be natural (jute, wood excelsior) or man-made (glass fiber).
- Surface should be well graded and smooth to insure adequate contact between soil and matting.
- Edges should be anchored carefully to prevent slippage.
- Materials should allow moisture to penetrate.

COMMENTS

- Matting is a useful emergency eroison control measure.
- Man-made matting fibers are persistent and therefore valuable in areas subject to heavy traffic even after vegetation is established.
- May be used in conjunction with or instead of mulching.
- See Appendix 6 for Installation Instructions.

MULCHING

Protective temporary covering spread over areas exposed for < 6 months or when seeding does not have a suitable growing season.

CONSTRUCTION GUIDELINES

- Materials and rates:(6)

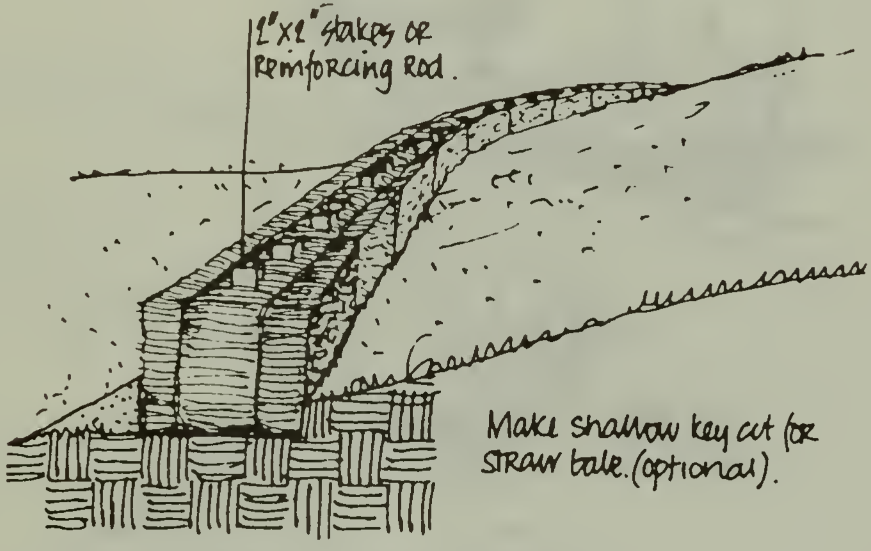
Mulch Material	Quality Standards	Application Rates Per 1000 $Ft.^2$	Depth of Coverage	Remarks
Compost or Straw Manure	Well shreded, free from excessive coarse material	400-600 lbs.		Excellent moisture conservation. Resistant to wind blow.
Cornstalks, Shredded or Chopped	Air dried, shredded into 8-12" lengths	150-300 lbs.		Slow decomposition rate. Resistant to wind blow.
Hay or Straw	Air dried, free from weed, seeds and coarse material	75-100 lbs. (2-3 bales)	75-90%	Effective for more than 3 months. Subject to wind blow and needs anchoring.
Peat Moss	Dried, compressed and free from coarse material	200-400 $ft.^3$	2-4"	Excellent moisture conservation. Subject to wind blow unless kept damp.
Pine Straw or Needles	Air dried and free from excessive coarse material	50-90 lbs.		Resistant to wind blow. Decomposes slowly.
Peanut Hulls or Cocoa Beans	Air dried and free from excessive fine material	200-400 $ft.^3$	2-4"	Decomposes in 1 year. Good moisture conservation, but subject to wind blow.
Sawdust, Green or Composted	Free from coarse material	83-500 $ft.^3$	1-7"	Resistant to wind blow. Slow decomposition. Treat with 35/lbs/nitrogen/ton.
Shredded Sugar Cane-Bagasse	Air dried, well-shredded	200-400 $ft.^3$ (14-28 bales)	2-4"	Slow decomposition. Resistant to wind blow.
Tanbark	Air dried, non-toxic	300-400 ft.	3-4"	Excellent moisture-holding capacity.
Wood Chips or Shavings	Green or air dried, free from coarse material	500-900 lbs.	2-7"	Resistant to wind blow. Treat with 12 lbs/nitrogen/ton to prevent nutrient deficiency.
Wood Excelsior	Green or air dried 0.024" x 0.031" x 4"	90 lbs. (1 bale)		Decomposes slowly and subject to some wind blow.
Wood Fiber Cellulose (partly digested fiber)	Air dried fibers 3.7 mm or longer	25-30 lbs.		Should be applied with hydromulcher. Needs no anchoring.

- Mulch anchoring guide.(10)

Anchoring Method or Material	Kind of Mulch to be Anchored	How to Apply
1. Peg and twine	Hay, straw, or corn stalks.	After mulching, divide area into blocks approximately 1 sq. yd. in size. Drive 4-6 pegs per block to within 2" to 3" of soil surface. Secure mulch to soil surface by stretching twine between pegs in a criss-cross pattern on each block. Secure twine around each peg with two or more turns. Drive pegs flush with soil where mowing and maintenance is planned.
2. Mulch netting	Hay or straw, compost, wood shavings.	Staple light-weight paper, jute, wood fiber, or plastic nettings to soil surface according to manufacturer's recommendations.
3. Slit	Hay or straw, corn stalks.	Cut mulch into soil surface with a square-edged spade. Make cuts in contour rows spaced 18" apart.
4. Asphalt spray	Wood chips, hay or straw.	Apply with suitable spray equipment using the following rates: asphalt emulsion 0.04 gallons per square yard; liquid asphalt (rapid, medium, or slow setting) 0.10 gallons per square yard.

STRAW BALES

Temporary devices for intercepting runoff and trapping sediment. Straw bales can be used as dikes, around storm drain inlets, across ditches, on slopes, or along stream banks.


2"x2" stakes or reinforcing rod.
Make shallow key cut for straw bale. (optional).

STRAW BALE FILTER BARRIER. perspective section not to scale.

(9)

Construction Guidelines

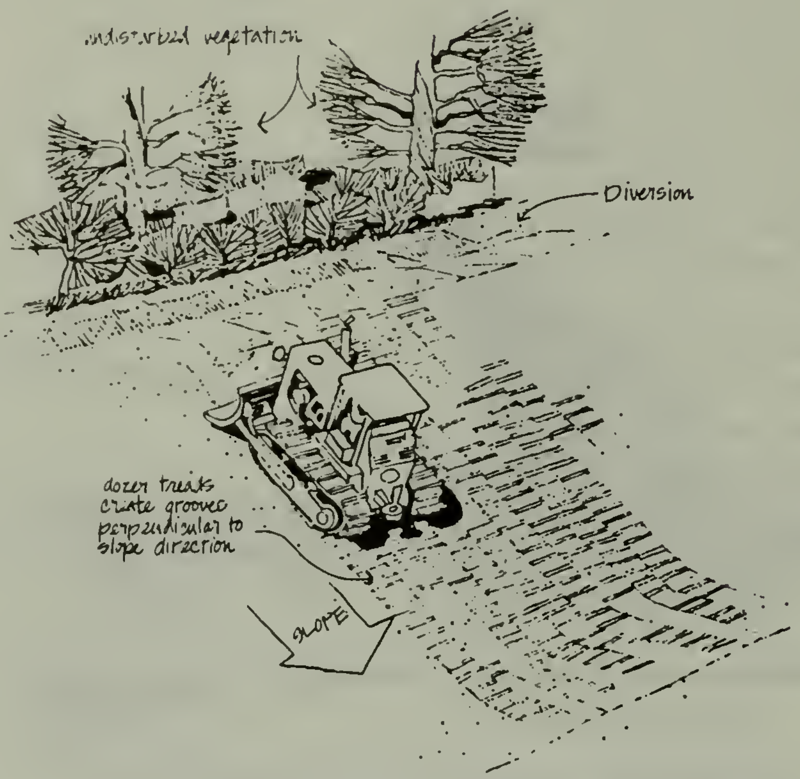
- Bales should be staked securely.
- To prevent runoff from undercutting bales, they should be set at least 6" into bottom of drainageway and compacted with soil along the upstream side.
- Wire or nylon bound bales are more durable than twine bound.

Comments

- Effective only on small area, <1 acre.
- Bales deteriorate in 2-6 months and must be replaced.

SCARIFICATION

Temporary method of reducing erosion on disturbed soils by mechanically cultivating along the contours to create small ridges which act like diversion channels.


undisturbed vegetation
Diversion
dozer treads create grooves perpendicular to slope direction
SLOPE

UNVEGETATED SLOPES SHOULD BE TEMPORARILY SCARIFIED TO MINIMIZE RUNOFF VELOCITIES

(4)

CONSTRUCTION GUIDELINES

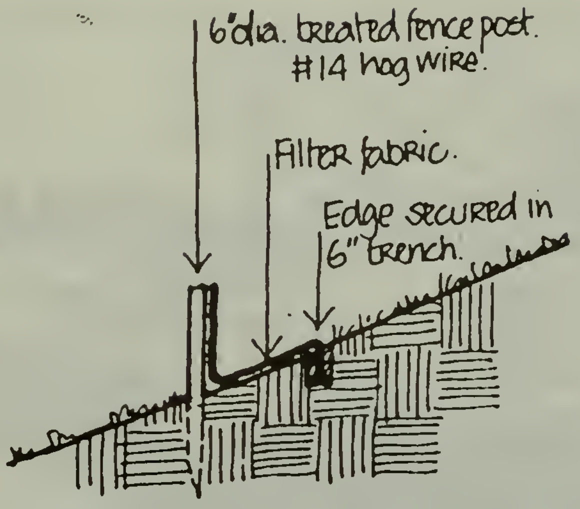
- Only for use on soil which will be bare < 3 months.
- Grooves should be embedded perpendicular to the slope direction.

COMMENTS

- Effective only for small storms.

FILTER FENCE

Fence constructed across a slope to intercept runoff and precipitate sediment.



FILTER FENCE. Section. not to scale.

(6)

Construction Guidelines

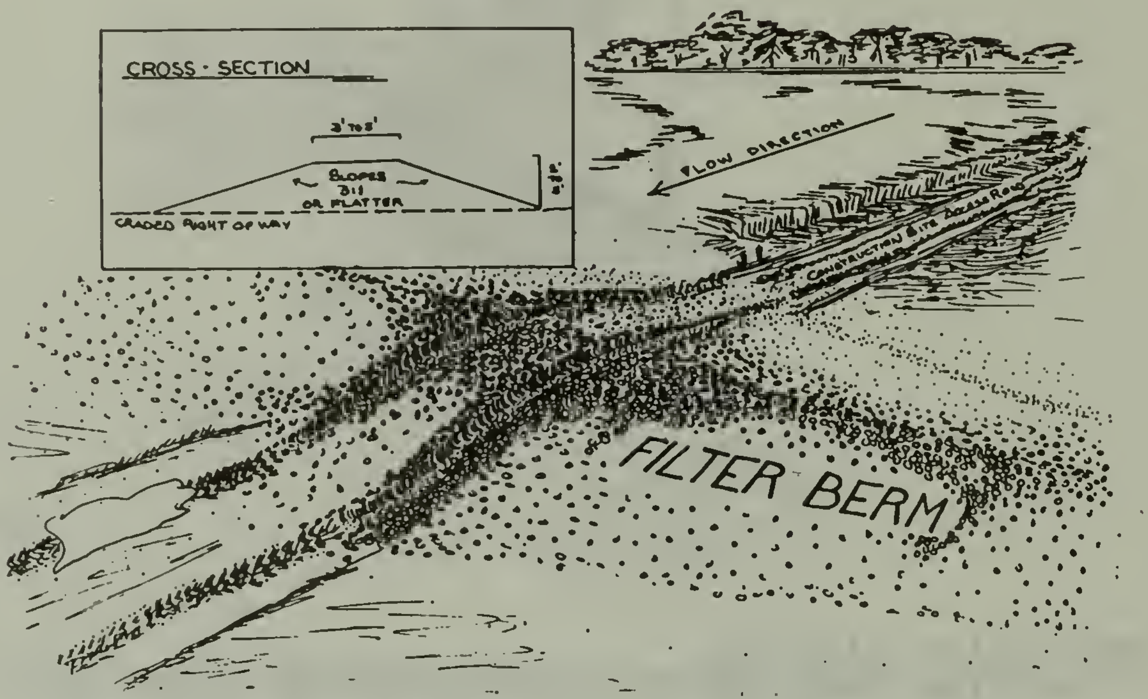
- Filter fence should be constructed of filter cloth attached to a wire fence or two fences 24" apart tightly packed with brush, straw or pine branches.
- Wire fence is constructed of T-section steel fence posts and 6" x 6" square mesh.
- Filter cloth is draped over the fence on the uphill side and buried in a 6" deep trench.

Comments

- Single fence highly effective on eroding slopes.
- Double fence effective across swales and grass channels.
- Accumulated sediment must be periodically removed.
- Brush within double fence must be periodically replaced.

FILTER BERMS

Temporary ridges of porous material constructed across a slope or graded right of way to retard runoff and filter sediment.



CONSTRUCTION GUIDELINES

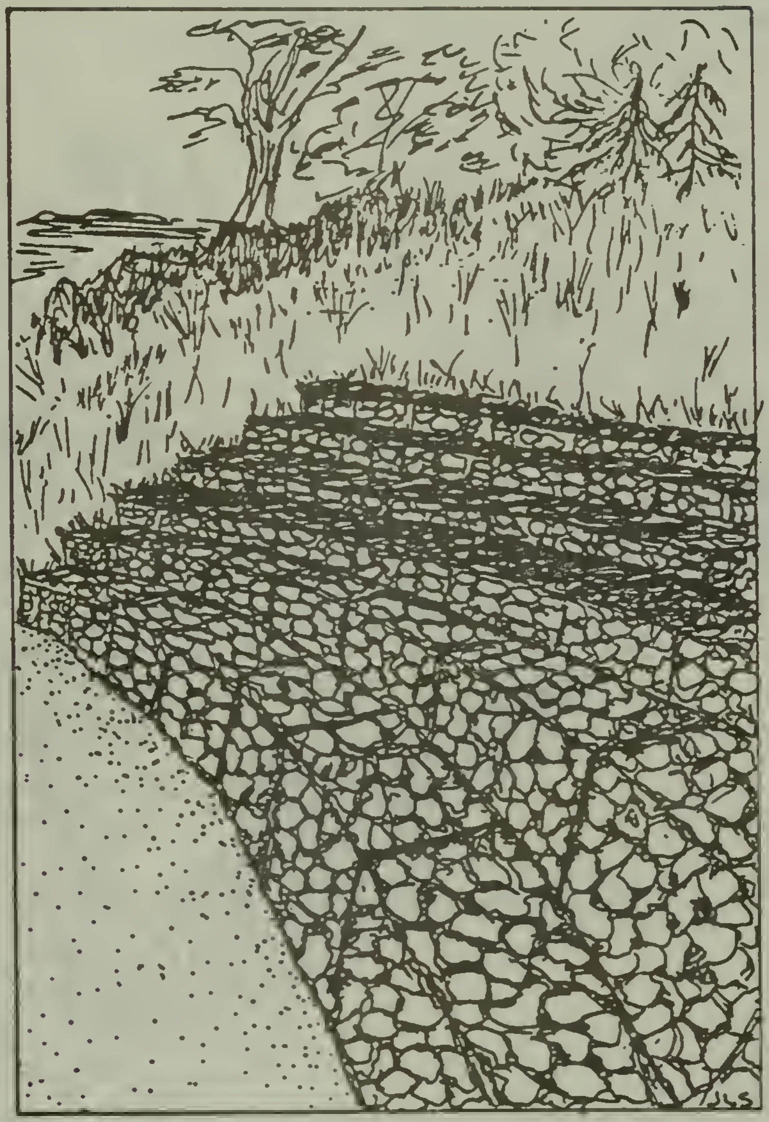
- Ridges are composed of 3/4" - 3" well graded gravel or crushed rock with ≤ 5% fines, and spaces are 200 - 300' apart.
- Ridges are generally 1½ - 2' high and 3 - 5' wide with sides having a slope of 311 or less.

COMMENTS

- Sediment removal or replacement of filter material periodically required.

GABIONS

Rock filled wire mesh boxes fixed together to form flexible permeable blocks for protecting streambanks.



CONSTRUCTION GUIDELINES

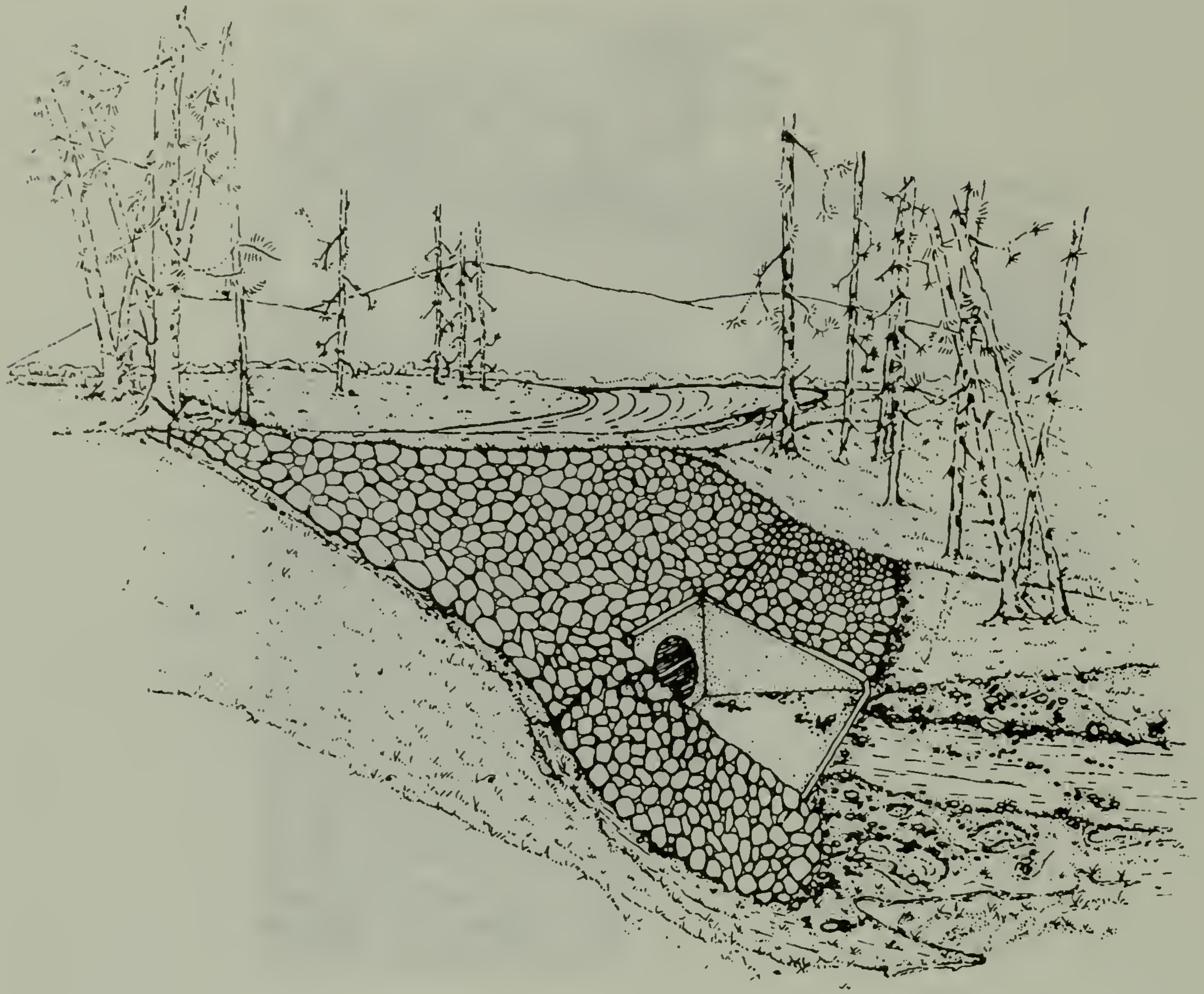
- Gabions should be formally designed by a professional familiar with their use.
- Each basket should be filled with 4" to 8" diameter stone in three layers with connecting wires between each layer to prevent distortion.
- Adjacent gabions should be woven together at contact surfaces.

COMMENTS

- Edges of gabions should be periodically inspected for undercutting or excessive erosion.

RIPRAP

Type of revetment composed of broken rock, cobbles, or boulders placed on earth surfaces such as the face of a dam or the bank of a stream, for protection against the erosive forces of water.



(6)

Construction Guidelines

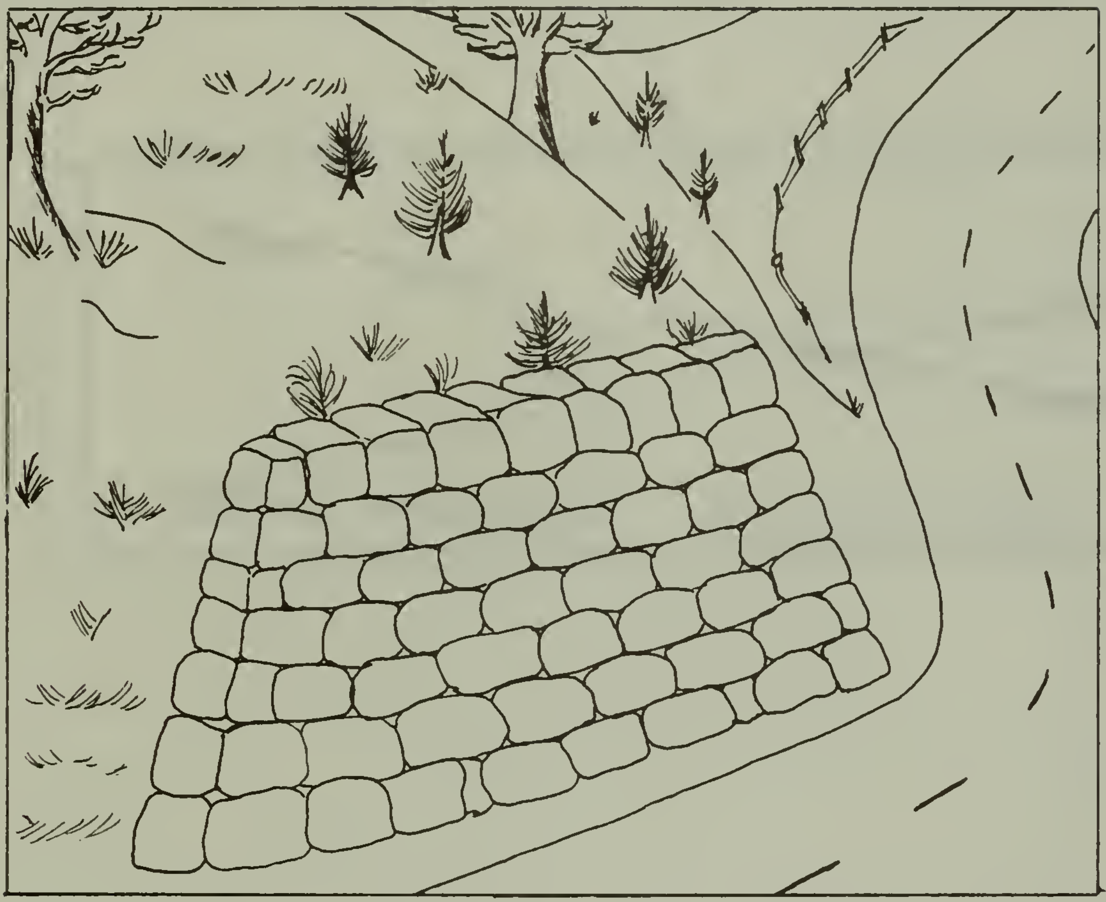
- Side slopes should be flatter than 1½ : 1.
- Filter material should be placed underneath riprap, unless the bank is a mixture of sand and gravel.
- Establish end of riprap 1.5' to 3' into channel bottom.
- Stone and filter material should be sized to velocity of channel.

Comments

- Only useful for channels with velocities of < 10ft/sec.
- Beneficial for unstable cut and fill soils.

RETAINING WALLS

Support designed to reduce extreme slope gradients.



CONSTRUCTION GUIDELINES

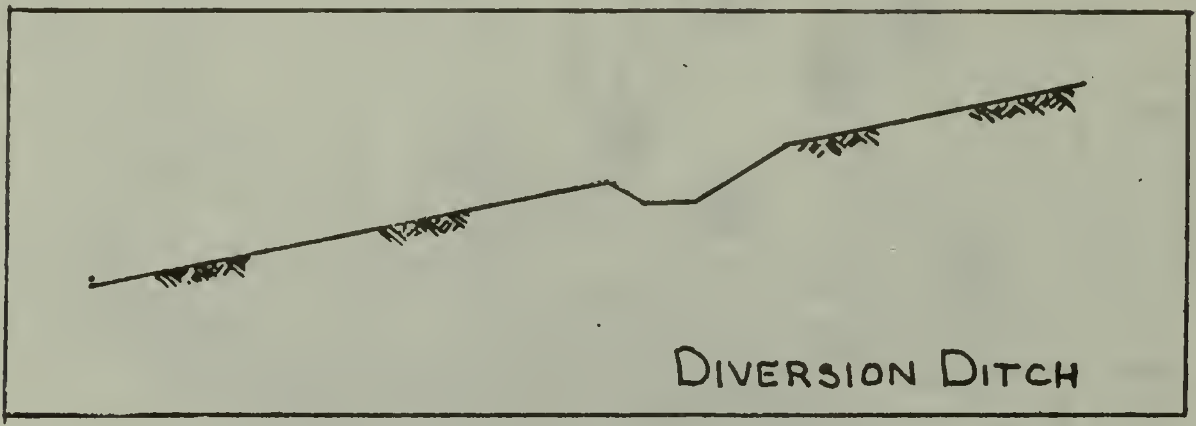
- Should be designed by a professional engineer.
- Acceptable materials include: concrete masonry, reinforced concrete cribbing, treated timbers, steel pilings, etc.

COMMENTS

- See also page 20 , gabions, and page 21 , riprap.

DIVERSION DITCHES

Channels designed to intercept and laterally divert runoff from slopes, thereby reducing runoff velcities and erosion potential. May be temporary or permanent.



CONSTRUCTION GUIDELINES

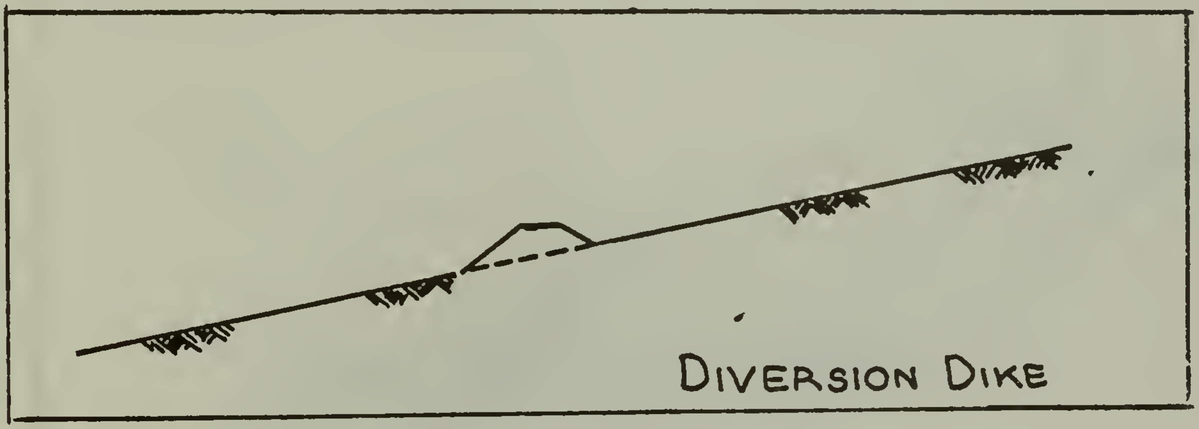
- Design considerations: (10)

Type	Life Expectancy	Location	Storm Frequency
Temporary	1 yr.	Construction areas	2 yrs.
		Building sites	5 yrs.
Permanent	1 yr.	Land areas, play-fields, rec. areas	25 yrs.
		Homes, schools, indust. buildings	50 yrs.
		Agricultural land	10 yrs.

- Side slopes should be stable and no steeper than 3:1.
- Outlet must not cause an erosion problem.
- If used in conjunction with diversion dikes,embankments should:
  - (1) Be $\geq$ 4.0 feet wide at design water elevation
  - (2) Include a 5% settlement factor
  - (3) Have a back slope no steeper than 2:1
  - (4) Be stabilized by seeding
- Periodic inspection and maintenance received.

DIVERSION DIKES

Embankments of soil (temporary) or other non-erodible material (permanent), designed to prevent overland flow across erodible areas and commonly used along slopes and roads.



CONSTRUCTION GUIDELINES

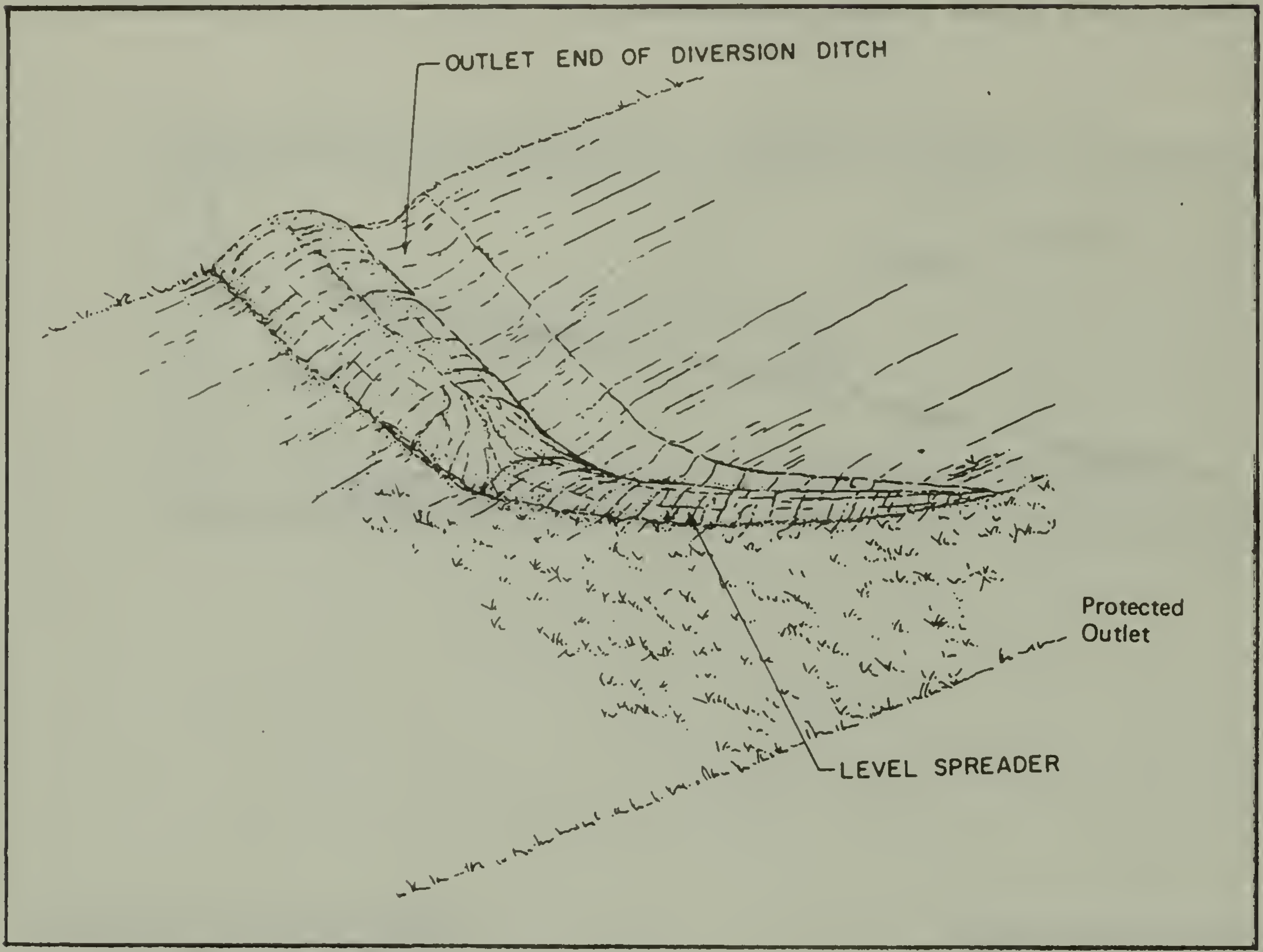
- Drainage area should not exceed 5 acres.
- Machine compaction of embankments is necessary.
- Positive grade of diversion dike should drain to a stabilized outlet.
- Embankments should be stabilized by seeding.
- Should be designed by a professional engineer.

COMMENTS

- Periodic inspection and maintenance is required.
- Temporary diversion dikes have a life expectancy of less than 1 year.
- Diversion dike may be used in combination with diversion ditches.
- See Appendix 2 for Seeding Directions.
- See Appendix 3 for Seed Mixtures.

LEVEL SPREADER

A shallow channel with a level section, excavated with undisturbed soil at the outlet end of a diversion structure, designed to diffuse the diversion flow.



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CONSTRUCTION GUIDELINES

Design Capacity (cubic/feet/second)	Minimum Length (feet)
10	15
11 - 20	20
21 - 30	26
31 - 40	36
41 - 50	44

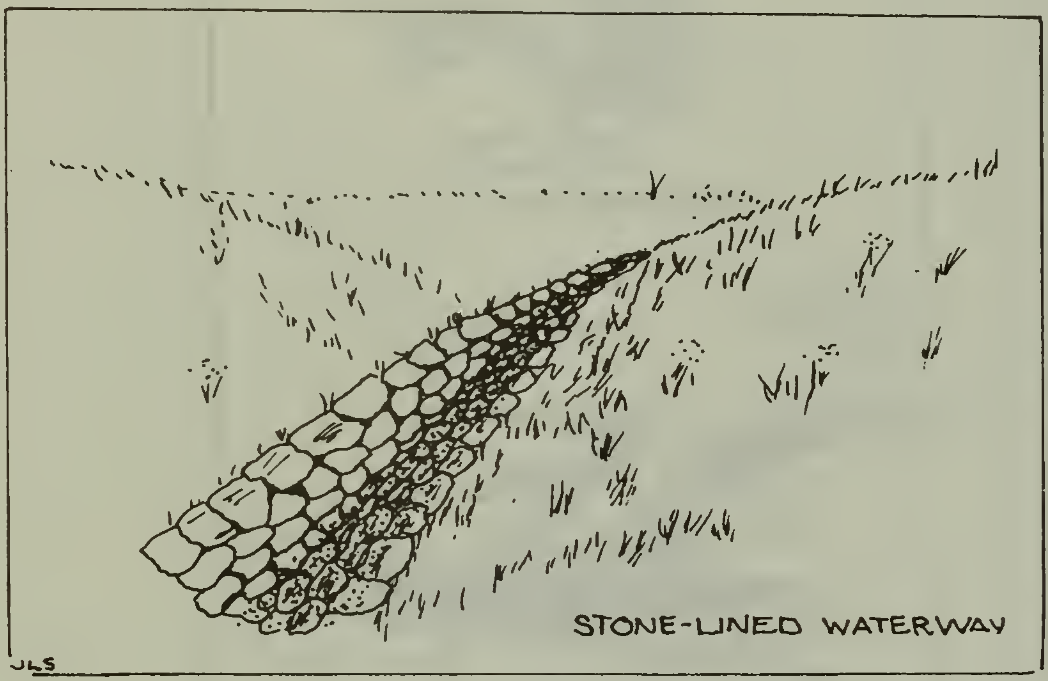
- Length should be based upon peak rate of flow from 10 yr. frequency storm.
- Excavate > 6" deep into undisturbed soil.
- Bottom and down stream lip should be level.
- Outlet should flow onto areas already stabilized by vegetation.

COMMENTS

- Periodic inspection and maintenance required.
- A basin behind the level spreader reduces the water velocity and causes sediment deposition.

LINED WATERWAY OR OUTLET

A waterway or outlet with an erosion resistant lining of concrete, stone or other permanent material used to provide the safe disposal of runoff where grassed waterways would be inappropriate.



CONSTRUCTION GUIDELINES

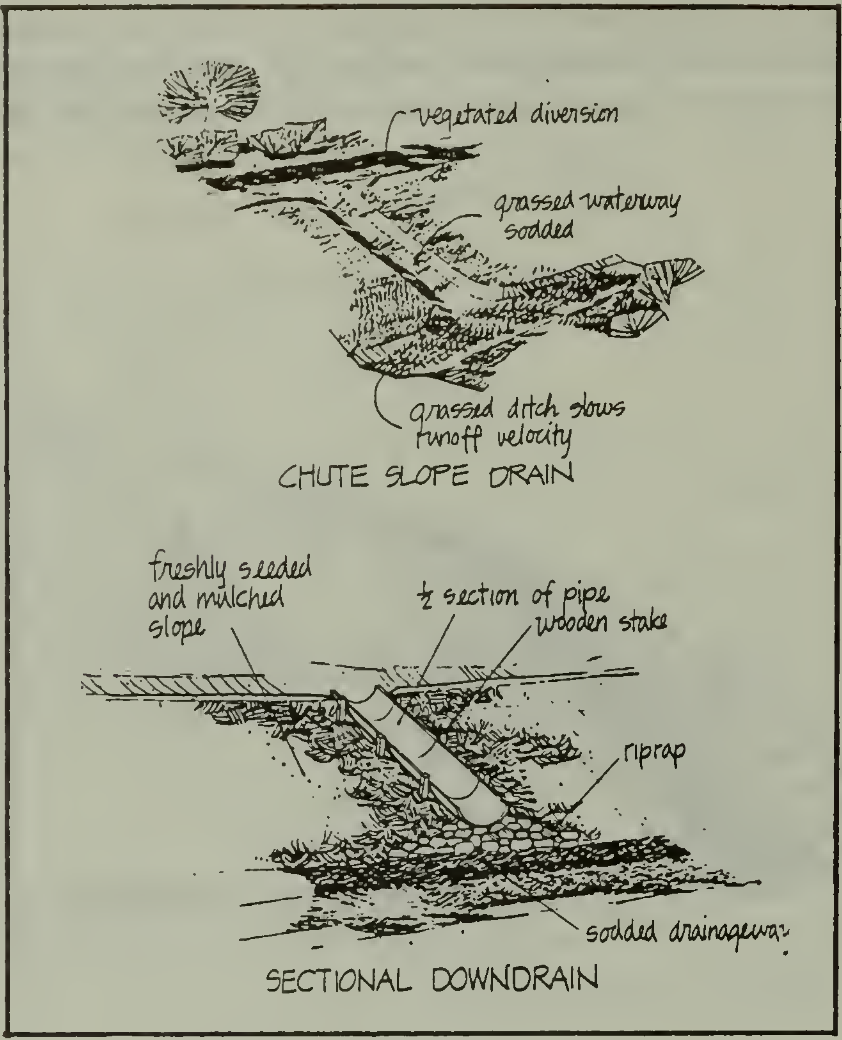
- Should be designed by a professional engineer or other qualified professional.
- Some typical materials used are:
  - Hand-placed formed concrete
  - Screened concrete
  - Mortared in-place flagstone
  - Slip form concrete
  - Rock riprap
- Side inlets, drop structures and energy dissipators meet the hydraulic and structural requirements of the site.
- Filters or bedding may be necessary.

COMMENTS

- Stone used for riprap should be dense and hard enough to withstand exposure to air, water and thawing.

DOWNDRAIN STRUCTURE

A conduit designed to transport runoff down a slope.



(4)

CONSTRUCTION GUIDELINES

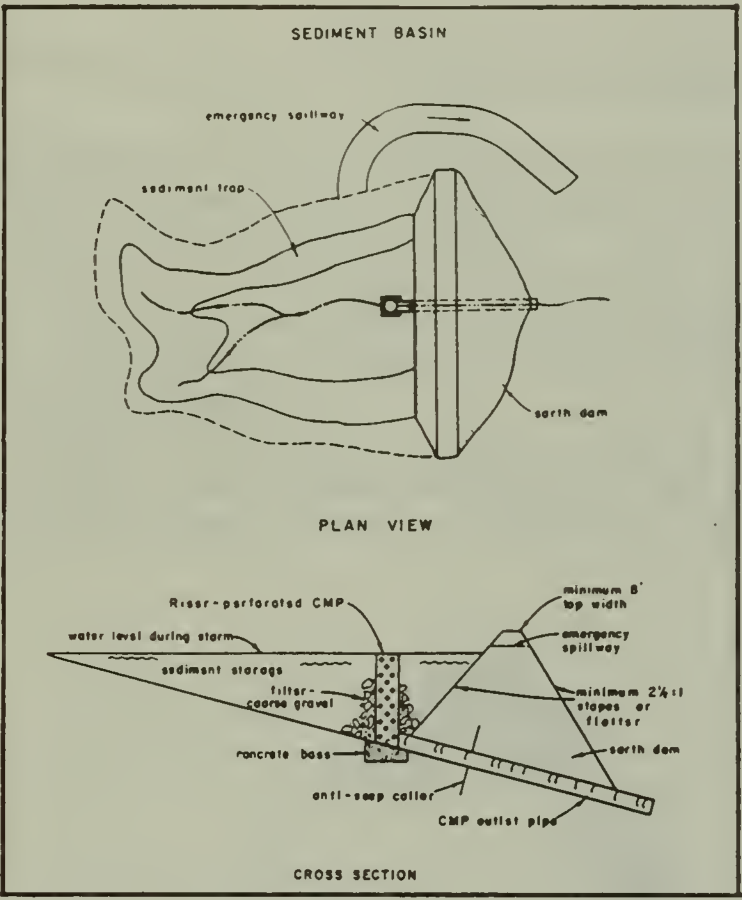
- Should be designed by a professional engineer to handle a 10 year storm.
- Chutes can be paved, or constructed of steel or plastic piping.
- Flexible piping should be used on fill slopes.
- Outlet to a stabilized area, such as gravel beds or sandy areas should be provided.

COMMENTS

- Periodic inspection required.

SEDIMENT BASINS

Temporary or permanent impoundments designed primarily for the purpose of sediment retention.



(10)

CONSTRUCTION GUIDELINES

- Should be designed by a professional engineer or other qualified professional.
- Drainage area usually less than 100 acres.
- Sediment basins should be cleaned out when effective capacity drops below 0.2" per acre of drainage (27 cubic yards per acre).

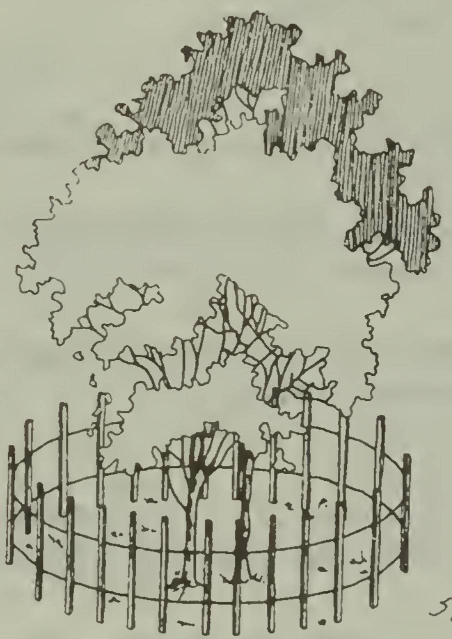
COMMENTS

- Methods designed to prevent erosion are preferable and sediment basins used as a last resort.

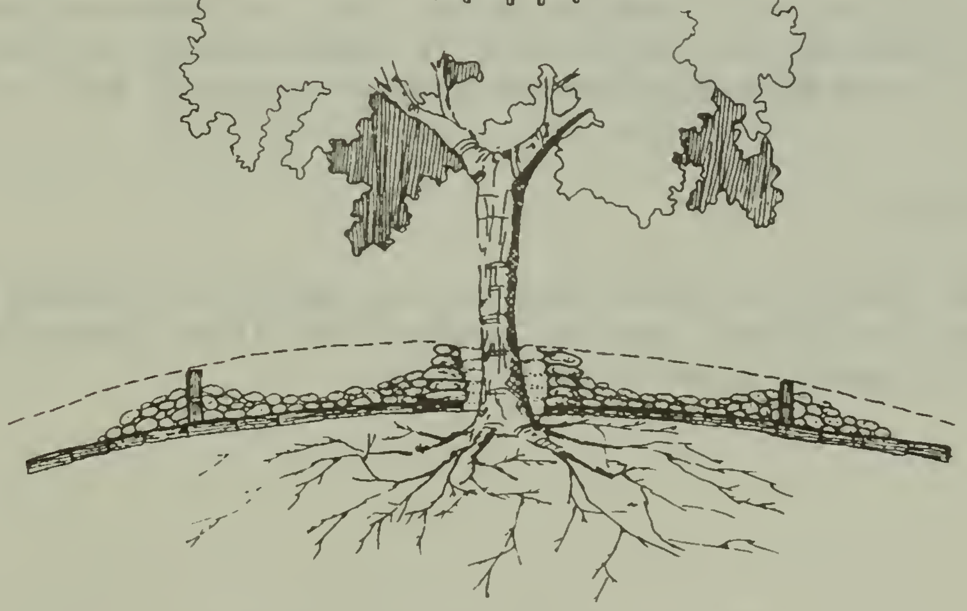
Appendix 1
Criteria for Protecting Trees and Shrubs(6)

The following criteria should be followed for trees and shrubs to be saved.

a. Preserve trees within right-of-way or construction strip that are identified to be saved on plans or marked in the field by red paint.
b. Do not disturb or cut roots unnecessarily.
c. Protect trees from emissions from motorized equipment.
d. Protect tree trunk, foilage, and root system with fences or other guards.
e. Remove shrubs to be saved, taking a sufficient earth ball at roots to maintain the shrub. Replace at completion of construction in condition equaling the original.



Correct fencing for tree protection.



Tree protection - tile and gravel will allow air circulation to root zone under a fill

Appendix 2
Seeding Directions(10)

1. Shape the surface to specified design, and smooth.
2. Lime according to soil test to pH 6.5; or in the absence of a soil test, apply lime at the rate of 2-3 tons of ground agricultural limestone per acre.
3. Manure at the rate of 10-15 tons per acre, if available.
4. Fertilize according to a soil test or, in the absence of it use the rate of 500 to 1,000 lbs. fertilizer per acre with manure; or 1,000 to 1,500 lbs. per acre without manure.

   For grasses:
   Use 10(N) - 10(P_2O_5) - 10(K_2O) or 10-5-5 or a similar analysis fertilizer.

   For legumes:
   Use 0-15-30 or 0-20-20 or equivalent analysis fertilizer.
5. Work up a seedbed 3" to 6" deep, thoroughly incorporating the lime, manure and fertilizer into the soil.
6. Cultipack or roll after seeding when slope conditions permit. If not, the seed should be raked into the top 1/4" of soil, or applied with a hydroseeder.
7. Seed during the period August 1 - September 15; or in the spring by May 15; or anytime during the growing season with irrigation.
8. Mulch with 1-2 tons of straw per acre. Hay or other material at equivalent rates may be substituted if weed seeding-in from the material will not adversely affect establishment of the desired vegetation.
9. Anchor the mulch.
10. Seeded areas should be fertilized during the first growing season after establishment and limed, manured and/or fertilized thereafter at periodic intervals, as needed based on soil tests.

Appendix 3
Seed Mixtures For Permanent Cover*(10)

TYPE OF SITE	MIXTURE	AMOUNT (lb's/acre)	COMMENTS
Excessively drained to somewhat excessively drained	Switchgrass	20	- Switchgrass requires chilling period of 3 wks. or longer except when seeding in late fall or winter
	Redtop or	2	- Do not mow regularly
	Annual Ryegrass	15	- Very slow growing 1st year
Well drained to moderately well drained	Red fescue	30	- Resistant to foot traffic
	Redtop or	2	- Tolerant to shade
	Perennial Ryegrass	15	- Good for lawn
Excessively drained to moderately well drained	Tall fescue	40	- Resistant to foot traffic
	Redtop or	2	- Tolerant to shade
	Perennial Ryegrass	15	
Well drained to very poorly drained	Reed Canarygrass	20	- On moist and very moist sites, reed canarygrass can be established quicker by planting rootstocks
	Redtop or	2	
	Perennial Ryegrass	15	
Somewhat excessively drained to moderately well drained	Crownvetch or	15	- Crownvetch and flat pea should not be seeded where regular mowing will occur
	'Lathco' flat pea	20	
	Redtop or Perennial	2	
	Ryegrass	15	- Spring seeding preferred
			- pH above 5.5
Well drained to moderately well drained	Kentucky Bluegrass	20	- Only on highly fertile sites
	Redtop or	2	- Spring seeding required
	Perennial Ryegrass	15	
Excessively drained to moderately well drained	'Tioga' Deertongue	15	- Tolerant of low pH and aluminum concentrations
Somewhat excessively drained to moderately well drained	Standard commercial grass or grass-legume mixtures used for lawns or long-term forage crop production	---	- Mixture should contain at least 75% perennial grasses or legumes - Annual fertilization recommended

* Other mixtures are available and can be used for most site conditions.

Appendix 4
Procedures for Sodding[10]

1. Shape and smooth the surface to the specified design.

2. Lime according to soil test to pH 6.5, or in the absence of a soil test, apply lime at the rate of 2-3 tons of ground agricultural limestone per acre (10-15 pounds per 100 square feet).

3. Fertilize according to soil test or at rate of 500 to 1,000 pounds per acre (1 1/4 - 2 1/2 pounds per 100 square feet) of 10-5-5 or similar fertilizer. Fertilizer with 40% or more of the nitrogen in organic form is preferred.

4. Work the lime and fertilizer into the soil 1 or 2 inches deep, and smooth.

5. The sod should be a dense bluegrass mixture, or comparable sod-forming species.

6. Cut the sod in strips 12 to 24 inches wide, 6 to 10 feet long, and approximately 1 1/4 inches thick. Roll with roots out to facilitate handling. Sod should be placed the same day as cut.

7. Lay strips of sod beginning at the lowest area to be sodded. Lay strips perpendicular to the direction of water flow. Wedge strips securely into place. Square the ends of each strips to provide for a close tight bond. Stagger joints at least 12 inches.

8. Trim the edges of the sod at all points where water enters or leaves the sodded area so that a smooth, flush joint is secured.

9. Roll the sodded area.

10. Irrigate, if possible.

11. When sodding is carried out in alternating strips or other patterns, the areas between the sod should be seeded as soon after the sodding as possible.

Appendix 5
Soil Moisture Conditions(10)

Excessively Drained. Sands and gravels to loamy sands. No effective moisture supply from seepage or high water table.

Somewhat Excessively Drained. Loamy sands to sandy loams. No effective moisture supply from seepage or high water table.

Well Drained and Moderately Well Drained. Sandy loams, fine sandy loams, loams, and finer; or corser textured soils with moderate influence on root zone from seepage or high water table.

Poorly Drained and Very Poorly Drained. All soils with the water table at or near the soil surface, or with enduring seepage.

Appendix 6
Installation of Matting(9)

Installation of Matting. Unreel matting up and down the slope. This is best achieved by placing a metal pipe through the center of the roll through which is passed a rope. By holding each end of the rope, the roll can be unwound slowly down the slope. Most mesh is reeled on a cardboard core and a rope may simply be passed through this. The material should not be stretched nor allowed to lie loosely, but to take up the contours of the ground. The manufacturer's recommendations for overlapping adjacent strips should be followed.

3:1 Anchoring. Unless properly anchored, mats are liable to slip. Uphill ends should be buried in a 6-in. -deep slot and stapled as shown (Figure 1) at 12-in. centers across width of the mat. At joints, the downhill end should be overlapped (shingle fashion). The uphill end of the new roll is inserted in a 6-in. slot (Figure 2) and stapled on 12-in. centers.

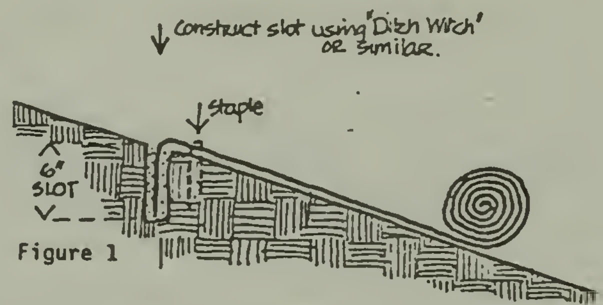


Figure 1

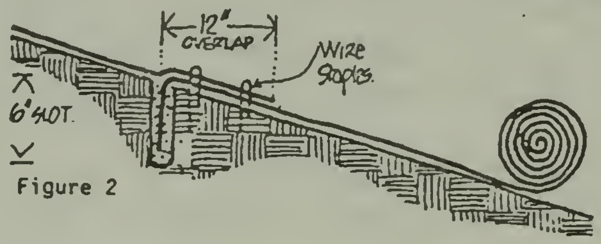


Figure 2

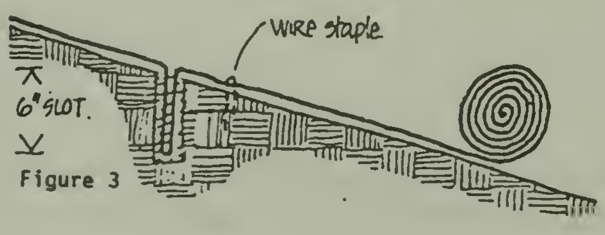


Figure 3

On very severe slopes check slots should be used. These are 6-in. -deep slots into which a tight fold of matting is inserted. The slot is filled and temped and staples inserted on 12-in. centers downslope of the check slot.

3:2 Stapling. Matting should be stapled according to the manufacturers instructions, but generally staples should be inserted on 12-in. centers down each edge of the mat and down its center line. Following installation, mesh matting should be rolled with a smooth roller to bring into close contact with the soil and to consolidate the seedbed.

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